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Appendix 1

Site descriptions and Figure S1

Site descriptions

Deseret-Sage and Deseret-Low are two distinct habitats located on the property of Deseret Land and Livestock, Woodruff, Utah. The 'Sage' habitat is a mixture of Wyoming big sage *Artemisia tridentata wyomingensis* and other shrubs with cool–season grasses dominated by western wheatgrass *Pascopyrum smithii* and a diverse array of herbaceous legumes and non–leguminous forbs. The 'Low' habitat was disked in the early 1960's to remove sagebrush and planted with the exotic perennial crested wheatgrass *Agropyron cristatum*, which has been the dominant species ever since. Both habitats are grazed by cattle on a managed rotational grazing schedule to remove 50% or less of forage, resulting in a moderate cattle biomass (13.6 kg ha^{-1}). Both habitats are also grazed by high biomass (5.5 kg ha^{-1}) of elk, deer and pronghorn in April–May and lagomorphs are highly cyclic and vary in biomass (0.1–2 kg ha^{-1}) (Ritchie unpubl.). Three fences of 30 × 30 m were erected at each site to exclude large (> 1 kg) herbivores. Climate data for all Deseret sites are from the Utah State Climatologist, Utah State University (pers. comm.).

Deseret-High treatment blocks of 30 × 30 m were located in a series of montane meadows each 3 km apart on Deseret Land and Livestock at approximately 2800 m elevation on the eastern slope of the Wasatch Range. These meadows were surrounded by aspen *Populus tremuloides* forest. The dominant vegetation is a species-rich mixture of perennial grasses and forbs dominated by bluebunch wheatgrass *Pseudoregneria spicatum* and Idaho fescue(*Festuca idahoensis*. The dominant large herbivores are elk (20.5 kg ha^{-1}) and domestic sheep which are herded briefly through the meadows in summer (9 kg ha^{-1}). Pocket gophers *Thomomys talpoides* were also excluded because the poultry netting prevented them from tunneling beneath the snowpack into plots in winter.

The Shortgrass steppe site is located at the Central Plains Experimental Range in north central Colorado. Treatment blocks were located on level uplands dominated by the dominant grass *Bouteloua gracilis* with moderate shrub density (*Atriplex canescens*) (Milchunas et al. 1989), at least 1 km apart and managed for cattle to remove 40% of primary production (Klipple and Costello 1960). Each block featured a 100 × 100 m cattle fence and a 30 × 30 m small-plus-large mammal exclosure constructed of barbed wire and hardware cloth in 1996. Lagomorph (rabbits and hares, three species) biomass averages 0.25 kg ha^{-1} and rodent (six species) biomass averages 0.37 kg ha^{-1}, compared to 0.14 kg ha^{-1} of pronghorn antelope and 76.3 kg ha^{-1} of cattle (Lauenroth and Milchunas 1991). Average rainfall data are from 1939–1990 (Lauenroth and Milchunas 1991), for 2001–2002: sgs.cnr.colostate.edu/Data/Category/Climate_WaterDynamics/ClmWtrDyn.htm.

Cedar Creek Natural History Area (45 km north of Minneapolis, Minnesota) featured six exclosures of 30 × 30 m in oak savanna vegetation which experiences prescribed spring fires 1 out of every 1–4 years. The principal herbivores are white-tailed deer and northern plains pocket gophers *Geomys bursarius*. Deer densities are 11–15 kg ha^{-1} (Knops et al. 2000). A large mesh fence excluded deer, and no small mesh was applied since rabbit densities were virtually zero at this site. Therefore only rodents were assumed to have access to the plot. The vegetation consists of an open canopy of *Quercus ellipsoidalis* and *Q. macrocarpa* with an understory dominated by native tallgrass prairie grasses (*Sorghastrum nutans*, *Andropogon gerardi*) and a highly diverse array of herbaceous forbs and legumes. Average rainfall is from 1982–2000, all data from: <www.lter.umn.edu/weather>.

Konza is a tallgrass prairie reserve in the Flint hills of northeastern Kansas (Knapp et al. 1998). Herbivore impact was measured in three different watersheds outside and inside the large fence (3 m high electrified separated strands of smooth wire) that contains the site's bison herd, managed to attain a biomass of 120 kg ha^{-1} since 1987 (Knapp et al. 1999). White-tailed deer are abundant at 9–15 kg ha^{-1} (Van der Hoek et al. 2002). Since deer can pass through the bison fence, herbivore impacts were measured by sampling a 30 × 30 m plot inside the bison fence and inside similar–sized deer exclosures (2.2 m tall, barbed wire strands 0.25 m apart) were both large herbivores were excluded. Rabbits and rodents are rare at Konza (< 0.1 kg ha^{-1}) and were not manipulated. The vegetation is dominated by C_4–prairie grasses (*Andropogon gerardii*, *Schizachyrium scoparius*, *Sorghastrum nutans* and *Panicum virgatum*) interspersed with numerous forbs. Average rainfall is from 1899–1996 (Hayden 1998), data for 2001–2002: <www.konza.ksu.edu/data_catalog/meteoro/>.

Junner Koeland is a 100-ha river floodplain grassland along the river Overijsselse Vecht in the Netherlands, managed as a nature reserve. The area used to be communal grazing land for the farmers from a nearby village, and has probably been grazed by livestock since medieval times (Bokdam 1987). The area is currently grazed by cattle at a biomass of 180 kg ha^{-1} from April until October. Main small vertebrate grazers are European rabbits *Oryctolagus cuniculus* that occurred at a biomass of approximately 12 kg ha^{-1} during the study period (Bakker et al. 2004). Five blocks of two 12 × 12 m plots were subjected to two grazing treatments in 1994: unfenced and fenced to exclude both rabbits and cattle (1 m tall poultry netting with 2.5 cm mesh). The vegetation consists of a matrix of lawn-forming grasses (*Festuca rubra* and *Agrostis capillaris*) interspersed with subordinate forbs (Bakker and Olff 2003). Flooding of the river occurs infrequently, (3 times over the last 20 years). Average rainfall is from 1971–2000 (KNMI 2002), data for 2001–2002: <www.knmi.nl/klimatologie/maandgegevens/index.html>, which are data for Twenthe airport, approximately 50 km southeast from Junner Koeland.

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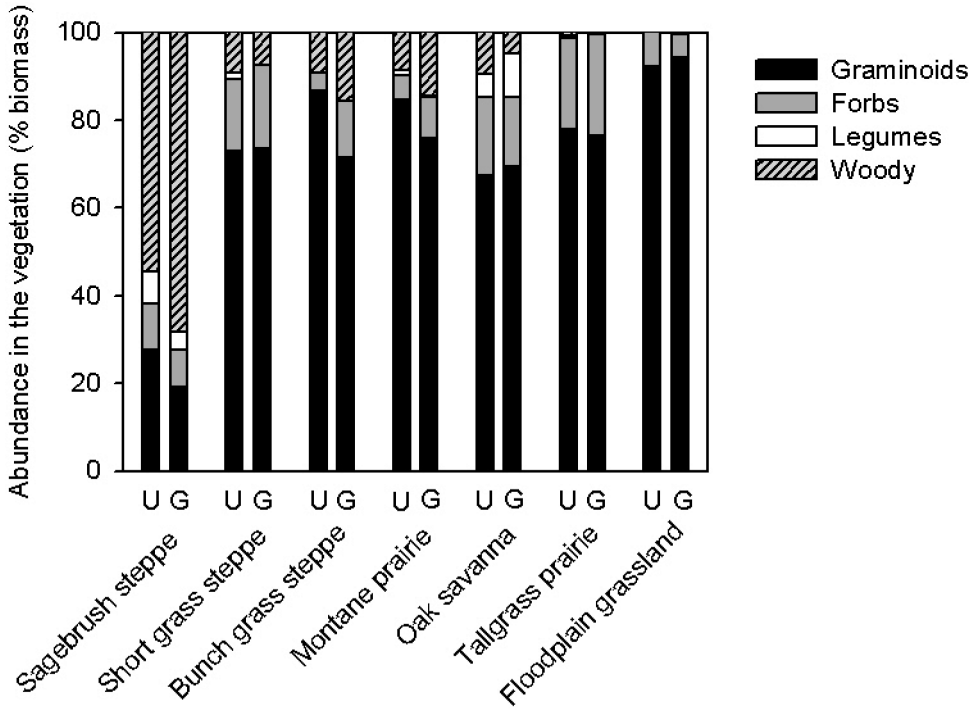

Figure S1. The abundance of functional groups (% biomass of standing crop) in the grazed and ungrazed plots at each site. U – ungrazed, G – grazed. The study sites were dominated by graminoids (mainly grasses) apart from the Sagebrush steppe, which was dominated by the woody forb big sagebrush *Artemisia tridentata*. Excluding herbivores did significantly affect the abundance of functional groups in the Sagebrush steppe (χ^2_3 = 10.97, p = 0.01), Bunch grass steppe (χ^2_3 = 10.90, p = 0.01) and Oak savanna (χ^2_3 = 8.29, p = 0.04), but not in the other sites.